Sunrise Powerlink Transmission Line Project
Application No. 06-08-010
MGRA Phase 1 Direct Testimony, Appendix A

APPENDIX A – POWER LINE OUTAGES AND WIND

A1. Data Sources

A1.1. SDG&E Outage History

Distribution: Open

Data Requests: MGRA-17, MGRA-32

File Name: Outages_summary.xls

Location: http://www.sdge.com/sunrisepowerlink/info/MGRADR2ReponseFeb6-07.doc

Description: Outage history for all SDG&E outage events for nine years for line voltages greater than 69kV. Contains 1611 outage records.

Fields: ID, kV, Outage Date/Time, Restoration Date/Time, Description, Component Affected, Field Notes

Restrictions & Limitations: outage history began Jan 1, 1998 and runs until Dec. 31, 2006. SDG&E was requested to provide data for lines of 69 kV and greater. There are no well-defined criteria for specifying whether an event is a "wind" event or not, hence one would expect the classification to be somewhat subjective.

Processing: Converted into database.

A1.2. Mesowest Weather Data

Distribution: Open

Location: http://www.met.utah.edu/mesowest/

Description: Data for RAWS and other weather stations in a database searchable by web interface. Hourly data can be obtained for any date extending back to the time that collection started for a particular station. This data is displayed in graphical (and optionally tabular) form for windows extending from 12 hours up to 30 days.

Fields: Temperature, relative humidity, wind speed (sustained & gust), wind direction, precipitation

Restrictions & Limitations: Data for SD County RAWS stations goes back to 1999, with many coming on-line between 1999 and 2001. Non-RAWS stations sometimes lack wind gust data. Data quality is considered marginal for older data. Anomalous functioning can often be identified by "wild swings" in measurements for one parameter or another, or by missing blocks of data.

Processing: RAWS data was downloaded for a window surrounding key wind events with a width of at least 12 hours.

A1.3. Poisson statistics calculator

For determining confidence levels and statistical uncertainties for small values, the Poisson.rb calculator was used (available from M-bar Technologies & Consulting)[1]. This calculator estimates the probability of a random event occurring within a specified interval for a given distribution mean. It is used iteratively to determine 90% confidence levels. For a two-tailed distribution, this entails determining the 95% upper and 95% lower interval.

A2. Analyses

A2.1. Wind-caused outages

A2.1.1. Goal

To determine the rate of wind-related line faults for use in future projections.

Also, to determine the wind speeds necessary to cause extensive power line faulting.

A2.1.2. Description

According to the Power Line Fire Prevention Field Guide[2] and other sources, wind events can cause power line faults which lead to arcing, which subsequently can ignite wildland fires. The primary failure mode that is relevant in the case of SPL is line vibration, which leads to increased stress and component failure. Tree contact is not expected to be a factor, due to infrequency of this type of vegetation along the route and the height of the lines. SDG&E outage records identify events where wind is a factor causing line faults.

A2.1.3. Methods

The SDG&E Outage History contains attributions for wind-caused events in the "Description" and "Field Notes" fields. Assuming these are accurate, we can collect the number of such events and the number of components affected.

To select these events, a selection was done on the text string "wind" and extracted to the file Wind-confirmed_outages_Mbar.xls.

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[1] Attached as Poisson.rb

[2] OSFM, CDF, USFS, PG&E, SC Edison, SDG&E; Power Line Fire Prevention Field Guide; Mar 27, 2001

Wind outage events were correlated with RAWS weather station data archived by Mesowest (Section A1.2). These data were analyzed for the maximum gust speed achieved within ± 12 hours of the beginning or end of the event window specified by the first and last events in the outage history for a given event. A wide window was chosen due to the consideration that weather events sometimes take time to pass through the area, so that the area experiencing the outage and affected weather stations may not experience the events contemporaneously.

A2.1.4. Analysis

All events in the SDG&E data were for 69 kV lines. No 230 kV or 500 kV lines were affected. Fourteen wind events were observed over nine years, causing a total of 126 outages. Six of these events attributed to wind caused a single outage, two caused a double outage, while the remaining six events were responsible for the 117 remaining outages. Of these, two events were responsible for a majority of the outages.

A wind storm from 2/9/02 to 2/10/02 caused 51 outages, and another on 3/29/03 was responsible for 42 outages.

Wind speed was collected for three data stations. More would have been better, but the number was restricted due to resource limitations. The three stations were chosen for wide geographic distribution, varied terrain, and proximity of two of the stations to the SPL path and SWPL path, respectively. These were Potrero (POTC1), Julian (JULC1), and the Camp Pendleton Ammo Dump (AMOC1). These are denoted by AMO, JLN, and POT in Figure A-1.

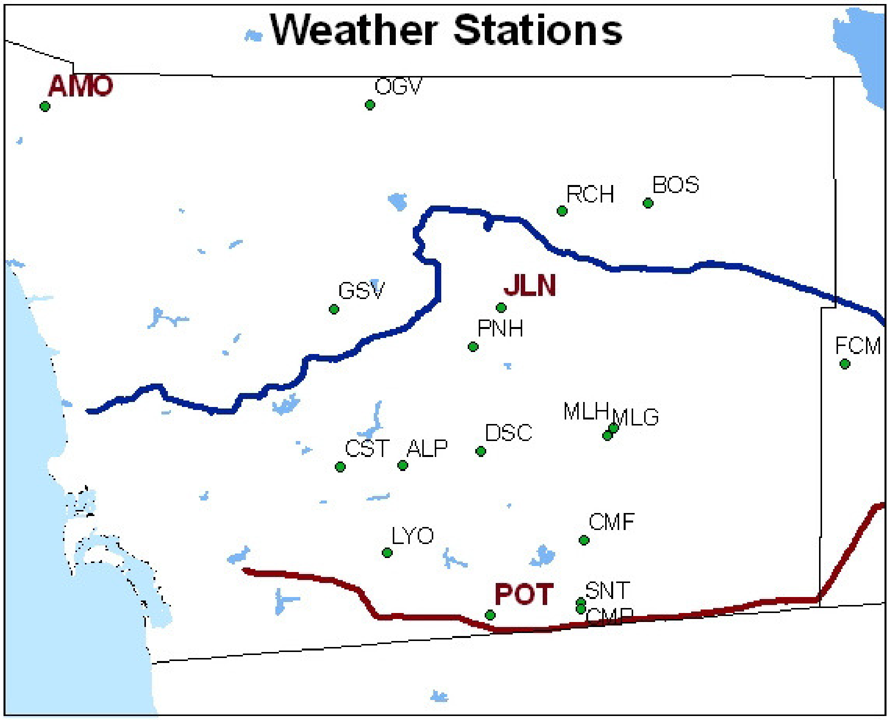

Figure A-1 - The figure indicates some of the weather stations in San Diego County. Those selected for comparison with SDG&E outage data were Potrero (POTC1), Julian (JULC1), and the Pendleton Ammo Dump (AMOC1). The location of these in the figure is indicated by the stations in bold red text (POT, JLN, AMO).

The results of this analysis are found in the Wind-confirmed_outages_Mbar.xls file, attached below. As can be seen, while the outage data goes back nine years, the weather stations have been operating reliably for only the last five. Of the fourteen observed outage events, only eight had data available from all three selected stations. Only these eight events are used in subsequent analysis. Of the eight, five of these were “Santa Ana” events, with very low relative humidity and easterly winds. The two events comprising the largest number of outages (93 out of 126) both fall into this category. The remaining three events were “winter storms”, with high humidity and possible precipitation.

Wind-confirmed_outages_Mbar.xls

File A-1 - Wind-confirmed_outages_Mbar.xls[3] - Outage data has been grouped into weather events, and these have been correlated with weather station data, including average and max wind gust, as well as relative humidity and wind direction.

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[3] Attached as Wind-confirmed-outages_Mbar.xls

Components fail and cause outages when they are stressed beyond their limits, which may change as they age. When stress increases beyond design limits, component failure becomes increasingly more probable. A component can fail when stressed at less than the design limit if it has a defect. Presented with the information that there were multiple outages, without corresponding location data, two possible scenarios are suggested. In one scenario, components experienced significant stress over a large portion of the service area, causing multiple failures. In the other scenario, components in a small area experienced extreme stress conditions with much larger probabilities of failure per component. In reality, these scenarios are not mutually exclusive and will occur in combination during a wind storm.

With this in mind, two metrics were applied to determine whether there was a correlation between the data of the selected weather station and the number of outages observed during the windy period. One was to select the mean of the weather station data, which would be a good representation of wind events that were geographically distributed, but would tend to “smooth out” and hide the significance of more localized events. The other method is to look at the maximum gust value experienced by any weather station. This will capture the extremity of localized events, but only if they occur near any of the weather stations.

The results of this analysis are shown in Figure A-2. As can be seen, the averaged wind speed seems to have a tighter spread than the maximum wind speed. The data show that there is a threshold below which wind-caused outages don’t occur (around 30 mph for the averaged data and 35 mph for the maximum wind speed data). Above this threshold, the number of outages rapidly increases. In the narrow range of this data set, this could be parameterized by a power law distribution with an exponent of approximately 1.5.

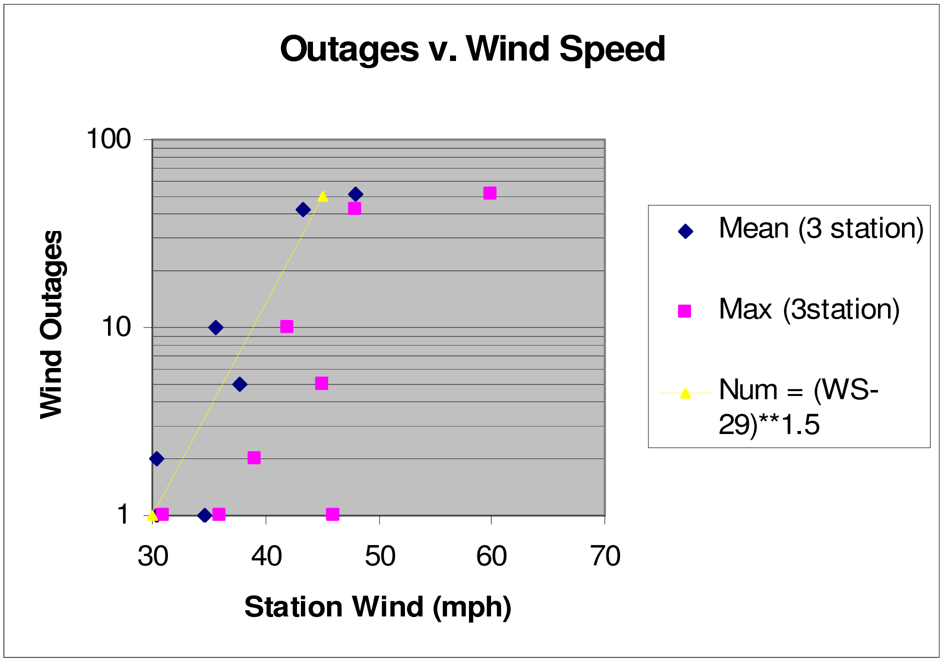

Figure A-2 - Number of power outages attributed to wind by SDG&E during various wind events measured against either the average or maximum value at the three selected weather stations (Potrero, Julian, Ammo Dump)

Assuming that the list of wind events provided by SDG&E is complete, we can estimate the frequency of wind initiated events as follows:

Fourteen wind events causing outages over nine years gives a rate of about 1.6 events/year. The 90% confidence interval for this estimate (based only on statistical uncertainty) is 1.0 to 2.3 events/year. Two major wind events (#outages >> 10) were responsible for most outages. The rate of these events was .22 events/year. The 90% confidence interval of statistical uncertainty for this value is from .088 to .55 (recurrence rate of 2 to 11 years).

A2.1.5. Limitations

Wind speeds (average and max) obtained from the three selected weather stations should *not* be taken to be those experienced by the outage area, which might have been greater or lesser. Neither is it implied that these are the conditions experienced along the SPL or SWPL routes. Three weather stations were chosen not because this is an optimal number but because of time limitations.

The number of events analyzed is very small due to the limited duration and comparative rarity of major wind events, leading to significant statistical uncertainty. Also, the weather stations were not reliably operational until about five years ago, so that only 8 of the identified 14 events had all sample stations providing good data.

Uncertainties in rate calculations are based only on statistical fluctuations, and do not include systematic errors. These calculations assume that the last nine years of history are typical of the future conditions. Climate change which alters the expected rate of high-wind events would throw these estimates off.

The power law used for the description of the dependency of the number of outages on wind is only a parameterization, and is not based upon a physical model. It should not be used for extrapolation.

A2.1.6. Conclusions

Power outages attributed to wind by SDG&E over the recorded nine year history occur infrequently, with fourteen instances observed. For the eight instances where weather station data was available, a positive correlation between wind intensity and the number of separate outages was observed. This correlation takes the form of a threshold, below which no excess outages are observed, above which the number of outages very rapidly increase with wind speed. Over the narrow range and limited statistics used, this increase can be parameterized by a power law with an exponent of about 1.5:

Equation A-1: $N \sim (w - b)^{1.5}$

where N is the number of outages, w is the wind speed, and b is the wind threshold (about 29 mph for the mean of the three weather stations used).

It was observed that all transmission line outages observed in the sample provided by SDG&E were for 69 kV lines. This implies that 230 kV lines and 500 kV lines have greater wind-resilience than do 69 kV transmission lines.

This analysis raises a couple of questions. The first is whether the assignment of wind-initiated events was complete and consistent. All events described as wind-caused were in fact correlated with elevated wind levels at weather stations around San Diego County. The question remains whether any other events were wind-initiated but not classified as such. This is addressed in the next section. The second question is whether the correlations observed over this limited data sample can be extrapolated, and furthermore how far it should be extended. The EIR should address what the maximum strength of an expected Santa Ana event will be within the lifetime of the project, taking into account possible climate change effects.

A2.2. Outage clusters – undetermined

A2.2.1. Goal

The goal of this analysis is to examine the remaining outages supplied by SDG&E and determine if they can be attributed to wind in spite of the fact they were not specifically tagged by SDG&E as being wind-caused.

A2.2.2. Description

The working hypothesis for this analysis, based upon observations made in the previous section, is that when high-wind events occur, they will result in correlated outages spanning the duration of the extreme wind event. We examine time-correlated events in the remaining outage data (wind-specific events removed) and look for clusters. These event clusters are then correlated with weather station data to determine whether there was extreme wind somewhere in San Diego County when the outages were observed. Also, outages of 230 kV and 500 kV lines were conducted individually in order to determine whether they were correlated with wind events.

A2.2.3. Methods

Outages have a wide range of causes. We examine the SDG&E Outage History (Section A1.1) to determine "legitimate" clusters of outage events. A filter was set up to remove all events definitely not due to wind that have known causes listed in their Description or Field Notes fields. This was done by constructing an SQL query on the database holding this information, with text strings that apply to known non-wind causes being used to remove the data from the sample. This SQL query is listed below as Equation A-2.

```
    SELECT [MGRA-17].[Outage Date/Time], [MGRA-17].[Restoration Date/Time], [MGRA-17].kV, [MGRA-
17].[Component Affected], [MGRA-17].Description, [MGRA-17].[Field Notes], [MGRA-17].ID

    FROM [MGRA-17]

    WHERE ((([MGRA-17].[Component Affected]) Not In ('Circuit
Breakers','Battery Systems','Regulators','Relaying','Transformers','Underground
Transmission Components')) AND (([MGRA-17].Description) Not Like '*epair*' And
([MGRA-17].Description) Not Like '*ind*' And ([MGRA-17].Description) Not Like
'*crew*' And ([MGRA-17].Description) Not Like 'Safety' And ([MGRA-
17].Description) Not Like 'Weed*' And ([MGRA-17].Description) Not Like '*ircuit
Break*' And ([MGRA-17].Description) Not Like 'Relay*' And ([MGRA-
17].Description) Not Like 'Tr*' And ([MGRA-17].Description) Not Like
'*Substation*' And ([MGRA-17].Description) Not Like '*lightning*') AND (([MGRA-
17].[Field Notes]) Not Like '*ontractor*' And ([MGRA-17].[Field Notes]) Not
Like '*car*' And ([MGRA-17].[Field Notes]) Not Like '*vehicle*' And ([MGRA-
17].[Field Notes]) Not Like '*wash*' And ([MGRA-17].[Field Notes]) Not Like
'*hydrant*' And ([MGRA-17].[Field Notes]) Not Like '*bird*' And ([MGRA-
17].[Field Notes]) Not Like '*lightning*' And ([MGRA-17].[Field Notes]) Not
Like '*ash*' And ([MGRA-17].[Field Notes]) Not Like '*phasing*' And ([MGRA-
17].[Field Notes]) Not Like '*wind*' And ([MGRA-17].[Field Notes]) Not Like
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'*storm*' And ([MGRA-17].[Field Notes]) Not Like '*crew*' And ([MGRA-17].[Field
Notes]) Not Like '*relay*' And ([MGRA-17].[Field Notes]) Not Like
'*maintenance*' And ([MGRA-17].[Field Notes]) Not Like '*ice*' And ([MGRA-
17].[Field Notes]) Not Like '*fire*'));
```

Equation A-2: SQL statement to exclude records that contain text in the Description or Field Notes field which indicates that the cause of the outage is well-known and that it is not due to winds.

Due to the smaller number of outages involving 230 kV and 500 kV lines, it was possible to examine each case individually in order to ascertain whether it was correlated with wind.

Multiple outages and 230kV/500kV data were correlated with RAWS weather station data archived by Mesowest (Section A1.2). These data were analyzed for the maximum gust speed achieved within ± 12 hours of the beginning or end of the event window specified by the first and last events in the outage history for a given event.

This information has been collected in the attached file *Undetermined_outages_Mbar.xls*.

Undetermined_outag
es_Mbar.xls

File A-2 – Outages where a cause was not found and which could potentially be due to wind were collected in the Undetermined_outages_Mbar.xls file. Event clusters and 230 kV/500 kV events were compared against weather station data[4].

Clustered events are depicted by coloring of adjacent cells, so that each colored block indicates a multiple-outage event. Additional fields were added to the original source file in order to track wind data and to tally statistics.

A large number of simultaneous outages (to within one minute) were recorded in the table. The assumption has been made that these are due to correlations on the grid having to do with electrical load, and as such were probably not due to wind, which has a much broader time distribution. These simultaneous events were removed from tallies by not including them in the "Clustered" data set (column H). "Non-simult" data set (column N).

Determining the significance of the correlations requires that we have an understanding of the frequency of significant wind events. It is necessary to know what the probability is of any given point in time occurring within a 12 hour window of a significant wind event. To achieve this, a list of 100 random dates and times was

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[4] Attached as Undetermined_outages_Mbar.xls

generated between Jan 1, 2002 and Dec 31, 2006. Using the same methods used for analyzing the outage data was examined in the ± 12 hour windows around the randomly generated events for the weather stations AMOC1, POTC1, and JULC1. Maximum and average values were calculated. This data can be found in *Random_wind_events_Mbar.xls* (see section A2.3).

A2.2.4. Analysis

A2.2.4.1. Outage clusters

Of the 1611 outage records in the Outage History File provided by SDG&E, 483 do not have well-defined causes as determined by the cuts described in the previous section. These outages are summarized in *Undetermined_outages_Mbar.xls* (File A-2). Of these 483 events, 43 were "simultaneous" events attributed to correlated electrical outages, and these were removed from the sample, leaving 440. This remaining sample was grouped into clusters, and the size of the clusters were tallied. This information is summarized in Table A-1.

The raw mean interval between outages for a nine year (3286 days) sample is 7.5 days. This needs further adjustment for clustered events. The "excess events" generated by clustering is calculated in the "Cluster XS" column (O). When these are subtracted from the sample, the mean time between outage events is 9.7 days.

We expect that clusters will be formed by the random superposition of events, with a probability of (.5 days / 9.7 days), or about .05. Hence, for a collection of 440 events, we'd expect to find around 23 2-outage clusters formed by random superposition of events. In fact, we observe 26 such clusters, in good agreement with this expectation. However, if we look at larger (3 or more) outage clusters we'd expect to see a fall-off of a factor of 20 for each step upward in cluster size. Instead, we see a large excess of events with three outages or higher. Statistical calculations were performed based on a Poisson distribution, and the chance that these clusters occur through random association is negligible. Some causal linkage between the outage events occurring in clusters of three or larger can be assumed.

Number in Cluster	Number of Events	Expected Coincidences	Probability
2	26	23.0	0.29
3	13	1.17	5.60E-10
4	3	.060	4.00E-05
>4	7	.0033	1.00E-21

Table A-1 - Number of outage clusters observed versus cluster size. The number of coincidences expected by random combination is given in the third column, along with the probability of the observed result being a coincidence.

Weather station data was examined for all clusters of three events or more, following the method described in the previous section. Of the 23 clusters examined, only one had a “significant” wind event associated with it, with significant being defined as the average of the AMOC1, JULC1, and POTC1 being greater than 30 mph OR the maximum detected by any station being greater than 35 mph, in accordance with Figure A-1.

This event occurred on December 29, 2004, and resulted in three 69 kV transmission line failures, including a broken pole. Average wind speed for the three weather stations was 42 mph, and the maximum gust recorded was 52 mph at the Julian weather station. Unless contraindicated by other information that hasn’t to date been provided by SDG&E, this event should be considered a wind event and included in the sample determined in A2.1., which would increase the number of wind events to 15.

A2.2.4.2. 230 kV and 500 kV data

Because of the smaller volume of 230 kV and 500 kV outage data, it was possible to analyze individual outages using the same data selection and wind-data correlation methods applied in the previous section. In the period between 1/1/2002 and 12/31/2006, there were 31 outages of 230 kV lines, and 5 outages of 500 kV lines (Columns W and X in *Undetermined_Outages_Mbar.xls*).

Only one of these outages was observed to have a correlation with a wind event. This event occurred December 27, 2006, on a 230 kV line, and led to a 5 acre fire at Camp Pendleton (Appendix B).

A2.2.5. Limitations

Weather data for cluster analysis is only reliable back through 2002 for the stations being used. Some of the outage clusters between 1998 and 2001 could be wind related.

Ideally, it would have been good to analyze all undetermined outages, including single outages, for wind correlations. This was not possible due to time constraints.

A2.2.6. Conclusions

The classification of wind events by SDG&E is relatively complete, with only one clustered outage event and one single outage event being left out of the sample. Therefore, the conclusions reached in section A2.1 remain valid.

Interestingly, the single event that SDG&E neglected to classify as wind-correlated is the only 230 kV outage correlated with a wind-event in their outage record. It also led to a five acre fire on the Camp Pendleton Marine Base. In the fire record (Appendix B) supplied by SDG&E, this event *is* in fact correlated with high winds. Notably, the metrics associated with this event (Avg = 30 mph and Max = 40 mph) are in fact on the borderline of this analysis' "significance" criteria.

A2.3. Random Wind Data

A2.3.1. Goal

To calculate the probability of an outage occurring by chance during a wind event, without a causal connection, a control data set is necessary.

A2.3.2. Description

This is a control data set based upon randomly generated points in time. Weather data from the same weather stations used in the previous analyses were collected for these times and the same criteria for averaging and obtaining the maximum wind speed were applied.

A2.3.3. Methods

A random sample of 100 dates was generated in the range from 1 January, 2002 to 31 December 2006. Prior to 2002, the weather station data becomes very unreliable for the Potrero (POT), Julian (JUL), and Ammo Dump (AMO) stations used in the previous analysis.

Random dates and times were generated using the Microsoft Excel RANDBETWEEN function to generate four fields: Month, Day, Year, and Hour. These were then recorded, and the equivalent date searched at the three weather stations used in the wind analyses. The maximum gust speed was recorded at each of the stations. This is found in the attached file *Random_wind_events_Mbar.xls.*

Random_wind_event
s_Mbar.xls

File A-3 – This file contains the 100 randomly generated dates and times and the corresponding maximum gust value at the POTC1, JULC1, and AMOC1 weather stations occurring within a ± 12 hour window of that time. Averages and maxima for all weather stations are also calculated[5].

A2.3.4. Analysis

Of the 100 events generated, only 79 had good data at all three stations. These 79 events are used for the remainder of the analysis.

The distribution of average and maximum values for the three weather stations is shown below:

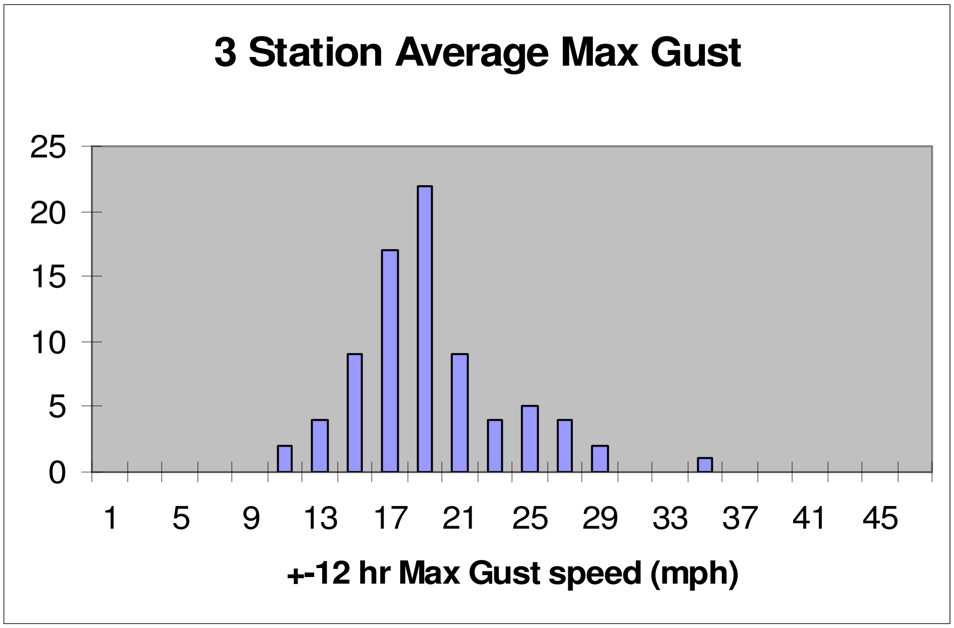

Figure A-3 – This figure displays a histogram of the maximum gust speed over a random 24-hour period averaged over the three weather stations POTC1, JULC1, and AMOC1. Seventy-nine events having good wind data at all stations are displayed.

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[5] Attached as Random_wind_events_Mbar.xls

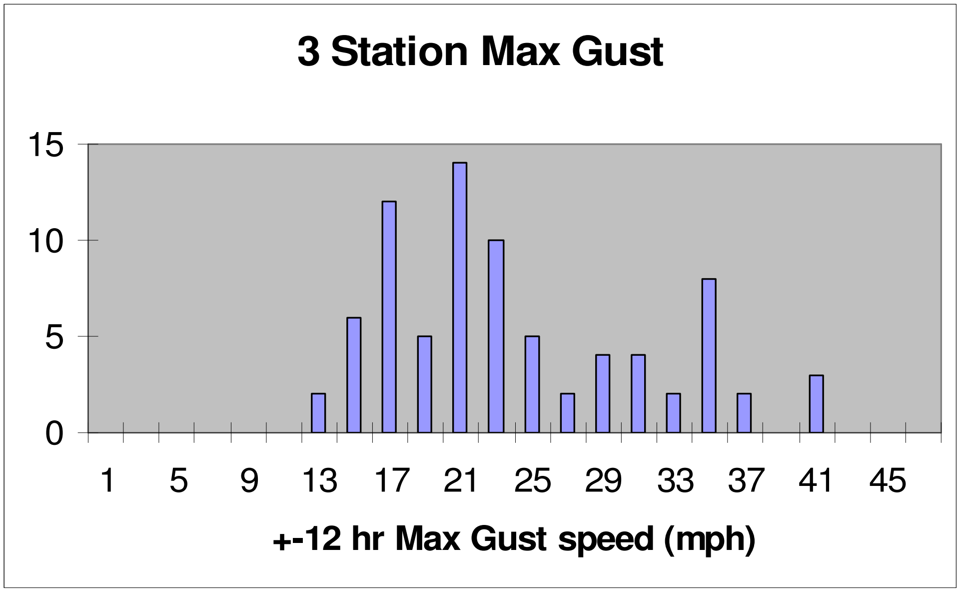

Figure A-4 - This figure displays a histogram of the maximum gust speed over a random 24-hour period over all of the three weather stations POTC1, JULC1, and AMOC1. Seventy-nine events having good wind data at all stations are displayed.

The criteria used in the previous sections for determining the significance of a wind event were Average > 30 mph or Max > 35 mph. As the above data demonstrate, there is a measurable chance of an accidental coincidence of a random event with a significant wind event due to the classification of the "Max" criteria. Five events were observed, giving a probability is around 6%. There is a smaller probability of coincidence using the "average" criteria, where only one event was observed and the probability is 1.3% with a significant range of uncertainty.

A2.3.5. Limitations

The general assumption made in this analysis is that there is a specifiable constant rate of "wind events" being generated per unit time, and that these events are independent of each other. Since weather patterns exhibit temporal correlations, however, the ideal average sampling distance should be much larger than any temporal correlation. This is almost certainly not the case with this analysis. Effects like this will tend to "amplify" or make more significant data patterns which occur in the data at the expense of other equally likely patterns which happen not to appear in the data due to random fluctuations.

Also, any long-term variations in the frequency of wind events would not be taken into account by this model.

It would have increased statistical power to have more than 79 good events in the sample. However, the number of events that can be picked and considered "random" is strongly constrained by the short time window of the study and the fairly broad (+- 12 hour) window in which the maximum gust speed was analyzed. Any more events and the windows begin to overlap. As is, the probability of overlap for 79 events occurring in a five year sample is around 4% (79/(5*365)).

It is likely that through narrowing the time window over which wind speeds were measured, these false positive rates could be significantly reduced. This could be done by getting the time of wind-induced failures and measuring what the appropriate window would be that captures the wind event at all three weather stations (for average) or at the most appropriate weather station (for maximum). However, since SDG&E seems to have adequately identified wind-induced events in the outage (and fire) data, this is not necessary.

A2.3.6. Conclusions

For any given random point in time between 2002 and the end of 2006, there is a roughly 6% chance (based on 5 events) that one of the weather stations used in these studies has a maximum gust speed greater than 35 mph within a 24 hour window around that time. If we average the three weather stations, this is roughly 1 % (based on one event).

A2.4. Transmission line fault rates

A2.4.1. Goal

We wish to determine a fault rate for transmission lines that describes potentially dangerous faulting that can lead to ejection of burning material which can ignite fires. This will be done for the 230 kV and 500 kV transmission lines and normalized on a per-mile basis. This should allow us to predict the fault rate for a completed SPL.

A2.4.2. Description

Outage information from the previous sections can be used to determine an overall fault rate per mile of transmission line if we know the total length of transmission lines in the system. This is distinct from the others sections in that this seeks to determine the base fault rate in the absence of wind. In this case, we are concerned whether randomly occurring faults along SPL might occur during a significant wind event, during which there is an elevated risk that they will initiate a wildland fire.

A2.4.3. Methods

A subset of *SDG&E Outage History* was generated that had additional cuts to remove all “Undetermined” events and to leave only those that specifically identify a fault, such as a flashover, a downed owned line, or damage to the pole structure. Events attributed to wind were also removed from this sample, as these are dealt with in Section A2.1.

The SQL query that was used to determine this sample is listed below:

```
     SELECT [MGRA-17].[Outage Date/Time], [MGRA-17].[Restoration Date/Time],
[MGRA-17].kV, [MGRA-17].[Component Affected], [MGRA-17].Description, [MGRA-
17].[Field Notes], [MGRA-17].ID

     FROM [MGRA-17]

     WHERE ((([MGRA-17].[Component Affected]) Not In ('Circuit
Breakers','Battery Systems','Regulators','Relaying','Transformers','Underground
Transmission Components')) AND (([MGRA-17].Description) Not Like '*epair*' And
([MGRA-17].Description) Not Like '*ind*' And ([MGRA-17].Description) Not Like
'*crew*' And ([MGRA-17].Description) Not Like 'Safety' And ([MGRA-
17].Description) Not Like 'Weed*' And ([MGRA-17].Description) Not Like '*ircuit
Break*' And ([MGRA-17].Description) Not Like 'Relay*' And ([MGRA-
17].Description) Not Like 'Tr*' And ([MGRA-17].Description) Not Like
'*Substation*' And ([MGRA-17].Description) Not Like '*lightning*' And ([MGRA-
17].Description) Not Like '*ndetermined*') AND (([MGRA-17].[Field Notes]) Not
Like '*ontractor*' And ([MGRA-17].[Field Notes]) Not Like '*car*' And ([MGRA-
17].[Field Notes]) Not Like '*vehicle*' And ([MGRA-17].[Field Notes]) Not Like
'*wash*' And ([MGRA-17].[Field Notes]) Not Like '*hydrant*' And ([MGRA-
17].[Field Notes]) Not Like '*bird*' And ([MGRA-17].[Field Notes]) Not Like
'*lightning*' And ([MGRA-17].[Field Notes]) Not Like '*ash*' And ([MGRA-
17].[Field Notes]) Not Like '*phasing*' And ([MGRA-17].[Field Notes]) Not Like
'*wind*' And ([MGRA-17].[Field Notes]) Not Like '*storm*' And ([MGRA-17].[Field
Notes]) Not Like '*crew*' And ([MGRA-17].[Field Notes]) Not Like '*relay*' And
([MGRA-17].[Field Notes]) Not Like '*maintenance*' And ([MGRA-17].[Field
Notes]) Not Like '*ice*' And ([MGRA-17].[Field Notes]) Not Like '*fire*'));
```

Equation A-3 - SQL query to determine outage events due to potentially dangerous faults. Undetermined events removed.

The results of this analysis can be found in the file *Outages_Faults_Mbar.txt*

Outages_Faults_Mbar.xls

File 4 – This file contains SDG&E fault data for events that were not wind correlated and that were found to be potentially due to flaws or faults in equipment[6].

We also refer to SDG&E response to data request **MGRA-18**[7], which specifies the following current estimates for transmission line lengths in its service area:

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[6] Attached as Outages_Faults.xls

[7] SDG&E'S 1/12/07 RESPONSE TO MGRA Data Request No. 1, p. 18

69 kV	884.2 mi.
230 kV	387.1 mi.
500 kV	158.2 mi.

Table A-2 - SDG&E estimates of transmission line lengths in its service area

A2.4.4. Analysis

Using *Outages_Faults_Mbar.xls* results and the SDG&E data in Table A-2, and the fact that there are nine years of collected data, we get the following estimates of fault rates per mile per year of transmission line:

Line Voltage (kV)	**Length (mi)**	**Faults**	**Fault rate ($yr^{-1}mi^{-1}$)**
69	884.2	191	.024
230	387.1	23	.0066
500	158.2	4	.0028

Table A-3 - Estimated fault rates for transmission lines in the SDG&E service area based upon nine years of data.

The greatest statistical uncertainty is in the 500 kV data, where only four outages were recorded over the measurement period. Based upon these statistics, using a Poisson distribution for the probabilities of a mean distribution resulting in an observation of four events, we get a 90% confidence range from 1.4 to 9.1 events (two-tail, with 5% below the lower range and 5% above the upper range). This results in a 90% CL for the 500 kV fault rate between .00098 and .0064 $yr^{-1}mi^{-1}$.

This allows us to make a prediction for the fault rate expected along the proposed SPL route. The proposed SPL route would consist of a 91-mile 500 kV transmission line and a 59-mile 230 kV transmission line. The expected fault rate on the 230 kV segment would be .39 faults / year, while the 500 kV segment would be expected to produce .25 faults / year (with 90% CL from .09 to .6 faults / year). Assuming the statistical uncertainty on the 230 kV segment is much smaller due to the higher statistics, we can expect an overall 90% CL fault rate from .48 to 1.0 faults per year along the SPL.

A2.4.5. Limitations

There is no assertion that every event in the outage history would be capable of generating the hot or burning material necessary to ignite a wildland fire, even in the case of extreme wind conditions. Determining fire probabilities requires a method of normalizing fire probabilities to time or faults. This is done in Appendix B.

The length of transmission lines in service, which was used to normalize this sample, may have changed somewhat over the last nine years during which the sample was collected.

A2.4.6. Conclusions

Fault rates along transmission lines in the SDG&E service area can be normalized to predict the rate along the proposed route of the Sunrise Powerlink assuming that the existing infrastructure is representative of that which will be in place over the service lifetime of the SPL. The observed fault rate for 230 kV transmission lines is .0066 faults per year per mile, whereas the estimate for 500 kV is statistics-limited and ranges from .00098 to .0064 faults per mile per year.

For SPL, this leads to a prediction of .48 to 1.0 faults per year along the entire length of the 230 kV and 500 kV segments.